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CURRENT LITERATURE

BOOK REVIEWS

Plant poisons and stimulants

The first volume of the Cambridge *Agricultural monographs*[1] covers a very much more restricted field than the title would lead one to expect, since it deals only with the effects, mainly upon the higher plants, of compounds of the five elements, copper, zinc, arsenic, boron, and manganese. Miss BRENCHLEY has previously published some of the results of work with these compounds which she has been carrying on since 1907 at the Rothamstead Experimental Station,[2, 3] these results being here brought together in connection with a résumé of certain portions of the related literature.

An introductory chapter of six pages points out that the classification of the elements into the three groups, nutritive, toxic, or indifferent as respects their action upon plants, no longer holds, and expresses the belief that no such simple grouping is possible. The second chapter describes the water culture methods employed by the author in her work, discusses the comparative advantages and disadvantages of water, sand, pot, and field experiments, emphasizes the necessity for caution in comparing results obtained by these different methods, and asserts that "all crucial experiments have always been and must always be done in water cultures." Then follow five chapters, each devoted to discussion of the physiological effects of compounds of one of the five elements employed. The subdivisions of these chapters deal with such topics as the occurrence of the element in higher plants, its effects upon growth when present alone in water cultures, when present along with nutrient or non-nutrient salts or with insoluble substances, its effects upon growth in soils, its action upon algae and fungi, and its effects upon germination of seeds and spores. A four-page chapter entitled "Conclusions" and a bibliography of 182 titles complete the work.

The general conclusions reached are that compounds of copper, arsenic, and in all probability those of zinc also, do not exert stimulatory effects in any concentration when added to water cultures of higher plants, but are toxic at all concentrations having a discoverable effect. A stimulatory effect of each of

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[1] BRENCHLEY, WINIFRED M., Inorganic plant poisons and stimulants. 8vo. pp. 110. *figs. 19.* Cambridge: University Press. 1914.

[2] BRENCHLEY, WINIFRED M., The influence of copper sulphate and manganese sulphate upon the growth of barley. Ann. Botany **24**:571–583. *pl. 47.* 1910.

[3] ———, On the action of certain compounds of zinc, arsenic, and boron on the growth of plants. Ann. Botany **28**:283–301. 1914.

these salts for such fungi as *Aspergillus* and *Penicillium*, and in the case of zinc, for the lower algae also, is definitely shown by the literature. Boron and manganese compounds in low concentration are stimulatory for higher plants; peas show stimulation by boric acid to a greater degree, by manganese to a less degree, than does barley. *Aspergillus*, *Saccharomyces*, and green algae are indifferent to high concentrations of boric acid, while there is no evidence in the literature that it is stimulatory at any concentration. The contradictory results obtained by RICHARDS and LOEW and SAWA as respects the effects of manganese upon fungi are reviewed, but no opinion is expressed.

The introductory chapter states that "a voluminous literature has arisen around the subject, and in the present discussion some selection has been made with a view to presenting ascertained facts as succinctly as possible. No attempt has been made to notice all the papers; many have been omitted perforce; it would have been impossible to deal with the matter within reasonable limits otherwise." A successful attempt of this sort requires that one have at least as great familiarity with what is left out as with what is included. But it must be said that Miss BRENCHLEY has not this knowledge, and that the character and importance of the omitted literature is such as to make the book very far from "a succinct presentation of the ascertained facts." For while the various chapters include discussions of the effects upon the fungi and the algae of the five elements under discussion, the citations made betray unfamiliarity with the literature; not only do they fail to give any idea of the enormous extent of the work done in this field, but they are by no means those which add most, either to the body of observed facts or to our present conceptions of the nature and effects of salt action upon lower forms. To cite important omissions would be to fill pages of this journal, and an example or two must suffice to illustrate a general situation. Thus, there is nowhere in the several sections dealing with change of form in algae and fungi when grown in salt solutions any mention of osmotic pressure as a significant factor; indeed the words do not occur in the book, and there is no reference to the work of KLEBS, LIVINGSTON, and the host of others who have furnished our present knowledge of this phase of the subject. Again, while the effects of copper sprays upon foliage, a subject which has long received particular attention at the hands of American physiologists and pathologists, is discussed to the extent of three pages, no American worker finds a place among the seven whose work is cited, and the most recent paper mentioned appeared in 1908. Such omissions would be surprising in any case; they become inexcusable when we recall that the very recent paper of PICKERING and the DUKE OF BEDFORD, certainly readily accessible to any English worker, not only furnished important results of work done at the Woburn Fruit Farms, but also admirably summarized the results of others up to the time of its publication. That the author reaches conclusions as to the effects of Bordeaux mixture upon assimilation and transpiration which are diametrically opposed to those of most recent workers, as for example REED and DUGGAR, is therefore not surprising. All the sections

dealing with the action of salts upon the lower plants are of this character, not only failing wholly to present the literature adequately, but making such bizarre selections therefrom as to force the conclusion that the papers discussed were brought together, like Cain's rejected sacrifice, "unculled, of such as came to hand." It is sincerely to be regretted that these sections of the book were not submitted to some physiologist or pathologist whose acquaintance with this field might have made of them a reliable summary of our present knowledge.

If those portions of the book which are concerned with higher plants had been intended simply as a compilation of results of authors who have recorded visible effects of salts on plants, they would have fallen short of the mark by reason of the many and important omissions both of American and of German work. But the work professes to be critical, and this it emphatically is not. The author nowhere gives expression to her own beliefs or convictions in clear, unmistakable terms, nor does she evaluate for us the ideas of others. Conclusions of the earlier workers, filled as they are with mistaken interpretations of results, are repeated without comment, and unproven assumptions and exploded theories stand side by side with established fact. Consequently, the reader not already thoroughly familiar with the literature will at once lose his bearings and grope his way blindly through a maze out of which he will carry at least as much of fundamental error as of "ascertained facts."

But it is in the sections dealing with the mode of action of toxic compounds upon protoplasm that the book is most vitally defective. The last ten years have been years of extraordinary advance in the study of protoplasmic permeability and of its modifications under the action of external agencies, and the facts gained in this field have been utilized by a host of workers in formulating theories of toxic and antitoxic action as phenomena arising primarily from modification of permeability. The literature dealing with these subjects is readily accessible and has, moreover, recently been summarized in new editions of CZAPEK'S *Biochemie* and HOEBER'S *Physikalische Chemie;* consequently there are few American physiological laboratories in which the new knowledge has failed to find its way into undergraduate instruction. Consequently it is amazing to find that the author of the book under review has nowhere mentioned any portion of this literature; that LEPESCHKIN, TRÖNDLE, CZAPEK, HOEBER, and RUHLAND are not mentioned; that the conceptions of salt action which we owe to WOLFGANG OSTWALD, MOROWITZ, FLURI, SZÜCS, PAULI, DERUFZ DE LAVISON, and HANSTEEN CRANNER, with a host of others, nowhere appear, and that the author's ideas of the whole subject are of the character generally held before 1900, when the ion-proteid theory of PAULI and LOEB appeared. A few examples will suffice to indicate this. The discussion of the nature of stimulation confounds increased permeability to water and consequent increase in green weight with true stimulation of protoplasmic activity, as on pp. 2, 3, 75, and this confusion exists throughout. One reads (pp. 40–41) that "it is very striking to see the desperate efforts that badly

poisoned pea plants make to reproduce themselves. . . . . In the greater strengths of such poisons as zinc and copper sulphate [*sic*] root growth is checked from the outset, but usually a very little shoot growth is made, and one frequently obtains ridiculous little plants about an inch high bearing unhappy and diminutive flowers, which are occasionally replaced [succeeded is meant] by equally unhappy and miniature fruits." The author fails to apprehend that the source and fount of all this woe is a lowered permeability for water, with a resultant development in which lack of water is the limiting factor. This is also the case with the plants of *Pisum*, *Phaseolus*, and *Zea* described on p. 18; the high concentration of copper sulphate here employed totally inhibited root development, but the resultant strong growth of tops, instead of being due to "stimulation of the shoots by some physiological process or other," as the author thinks, is exactly what we find wherever inhibition of root development, however caused, permits the utilization of the foodstuffs present in the seed solely in the development of aerial parts. The most remarkable passage in the book, however, is undoubtedly that on p. 27, in which we are told that "so long as the solution of copper salts is dilute enough, the absorption layer of the root, acting as a semipermeable membrane and upheld by the resistant protoplasm, is able to keep the copper out of the plant and to check its toxicity. As soon as a certain limit is reached the copper exercises a corrosive influence upon the outer layer of the root whereby its functions are impaired, so that it is no longer able efficiently to resist the entry of the poison. As the concentration increases it is easy to conceive that the harmful action should extend to the protoplasm itself." Just what this "absorption layer" may be the author does not tell us; it seems not to be protoplasmic, and inasmuch as it seems to combine the active rôle of Horatius at the bridge with the more passive function of the Holland dikes, physiologists will regret that we are told no more of its origin, functions, and relation to cell wall and protoplasm than has been quoted.

That the book is exceedingly disappointing will be obvious from these quotations. Physiologists have been awaiting the appearance of a résumé of the whole subject of toxic action which would bring together the extensive observations of the older literature and unify and explain them in the light of the new knowledge of the nature and behavior of the protoplasmic membrane. The author who successfully undertakes the task must have kept abreast of the literature in many fields; with the tremendous advances made in physical chemistry and in our knowledge of the colloids, no less than with the work done directly with the subject in hand, for most help will come from the literature of these related fields. It is just here that Miss BRENCHLEY has failed; her book merely collects a mass of observations which it will be the task of some future physiologist possessing wide training and a modern point of view to organize and explain.

There are various minor omissions and slips of the pen. Thus while formulae for two nutrient solutions are given on p. 13, we are nowhere told,

in the various sections dealing with experiments in which plants in nutrient solutions were employed, which of these was used in any particular case The description of HASELHOFF'S experiments (p. 25) leaves the reader to wonder whether each sample of soil was extracted with 375 liters of water, divided into 15 equal quantities, or with 25 liters used 15 successive times. The substitution of "below" for "above" in line 8, p. 30, would lead the unwary reader to conclude that the toxicity of copper is decreased as the concentration of the solution increases. The citations of literature are not numbered, and when a given author has a number of papers listed in the bibliography, the reader has no means of knowing what particular citation contains the results quoted in the text. While physiologists have universally adopted the terminology of the normal solution, concentrations are here written as parts per thousand or million, and when quotations from authors who follow the modern custom are made, normal solutions are sometimes converted to parts per million, sometimes have equivalents parenthetically introduced, and are sometimes carried over unchanged. Consequently, comparison of the figures is impossible without resorting to calculation. In the graphs showing dry weight of plants grown in various concentrations of salts, some one concentration, as 1/100,000, is chosen as a "unit," and other concentrations are written in the graph as multiples or fractions of this unit, making easy reference impossible. Those hyphenated and immortal acquaintances of our early youth, "carbo-hydrate" and "photo-synthesis," greet a surprised public in these pages once more, after a generation of absence from the ken of physiologists.

The concluding paragraph gives naïve expression to a point of view which physiologists had supposed to be happily confined to a certain rapidly decreasing class of agricultural workers in this country. After discussing the results obtained by physiological experimentation with manganese and boric acid and those obtained in field trials of stimulatory fertilizers, the author says, "the possibility now exists that in some respects the two lines of work are converging and that the more purely scientific line will have a big contribution to make to the strictly practical line." Those of us who regard plant physiology as the science of economic plant production had thought that the artificial lines of demarcation between "scientific" and "practical" work had long ago disappeared, and that future progress was to be made, not independently or along convergent lines, but by the common utilization of scientific facts and methods in the cooperative attack upon common problems. In view of the fact that the long series of publications from the Rothamstead Experimental Station have set a standard to which comparatively little of the agricultural literature of this country has attained, it is surprising that this book, with its lamentable deficiencies in grasp of subject-matter and in point of view, should have been issued as the initial number of a series of monographs whose general editors are Professor WOOD, of Cambridge, and Director RUSSELL, of Rothamstead. Closer editorial supervision would have withheld the book from publication

in its present form, and it is to be hoped that immediate and radical revision may make of it an acceptable and trustworthy guide to the literature of this interesting field.—JOSEPH S. CALDWELL.

NOTES FOR STUDENTS

Experimental embryology.—Morphologists and experimental workers have been aware for some time of a need of greater cooperation between their respective lines of research. Too often morphological or cytological studies are pursued without reference to important physiological conditions, while conclusions are drawn from experimental work which would not be warranted by morphology and cytology. It is becoming increasingly evident that results can be more properly interpreted in the additional light afforded by supplementary researches in a related field. The value of this cooperative method is emphasized in a recent paper by KUSANO[4] on angiosperm embryology. A favorable form for such study was found in the orchid *Gastrodia elata*. Since the inflorescence develops at the expense of material stored in a tuber, it is a simple matter to maintain the plant under normal nutritive conditions. Some of the results of KUSANO's research, which is still in progress, are cited below.

The normal development in *Gastrodia* is as follows: A subepidermal archesporial cell becomes the megaspore mother cell and undergoes the two maturation divisions. In some cases reduction, which is said to consist in a simple pairing and separation of the chromosomes on the equator of the spindle, fails to occur, so that the functioning megaspore and gametophyte are sometimes haploid and sometimes diploid. The embryo sac contains only 4 nuclei, 3 of which are organized as an egg apparatus. This reduced condition is regarded as an economical specialization correlated with the peculiar vegetative habit. Many irregularities which occur are related to poor nutrition. At fertilization, which occurs only in haploid sacs, one of the male nuclei fuses with the egg nucleus, while the other fuses with the single polar and a synergid nucleus. The fertilized egg forms the usual undifferentiated proembryo, which is nourished through the suspensor and large nucellar cells. The endosperm nucleus does not divide. The following time schedule was determined: two days before the flower opens the ovule is yet in a rudimentary stage; the embryo sac is completed 3 days after bloom; fertilization occurs the 4th day after pollination; the fertilized egg divides the 5th day; the seed is completed the 14th or 15th day; the capsule dehisces about the 23d day. This exceptionally rapid development (for Orchidaceae) is correlated with the fact that it occurs at the expense of stored food. Occasionally two archesporial cells arise in a single ovule and undergo complete development.

An extended series of experiments led to the following conclusions: After a few days the fertilizing power of the pollen is lost and the ovules become

[4] KUSANO, S., Experimental studies on the embryonal development in an angiosperm. Jour. Coll. Agric. Tokyo **6**:7–120. *pls. 5–9. figs. 28.* 1915.